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Characterization, classification and mapping of soils of Panja-Rao watershed, Saharanpur, Uttar Pradesh

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Abstract : Soils of the Panja-Rao watershed of Uttar Pradesh were studied using remote sensing technique, ground survey and laboratory analysis. Different physiographic units *viz.* Siwalik hill, structural hill, piedmont plain, alluvial plain and flood plain were delineated. Thirteen soil series were identified and mapped into nine soil series association. Soils are moderately deep to very deep, very dark grayish brown to yellowish brown, well drained, slightly acidic to alkaline, low to high in organic carbon and low to medium in cation exchange capacity with wide textural variations. Taxonomically, the soils of Siwalik hill belong to Typic Ustorthents and Typic Haplustepts; those of structural hill belong to Typic Haplustepts and Typic Ustipsamments; piedmont plain soils are classified as Typic Haplustepts, Typic Ustothents and Fluventic Haplustepts; alluvial plain are classified as Typic Ustorthents, Typic Haplustepts and Fluventic Haplustepts and those of flood plain are classified as Typic Ustifluvents.

Additional key words : *Soil Survey, remote sensing, GIS, soil morphology*

Introduction

Soils are considered as the integral part of the landscape and their characteristics are largely governed by the landforms on which they have developed (Sharma *et al.* 1999; Sawhney *et al.* 1992). Systematic study of morphology and taxonomy of soils provides information on nature and type of soils, their constraints, potentials, capabilities and their suitability for various uses (Sehgal 1996).

The present investigation carried out in Panja-Rao watershed of Saharanpur district, Uttar Pradesh highlights the spatial distribution, potential and limitation of soils for optimal utilization on a sustained basis.

Materials and Methods

The Panja-Rao watershed lies between $30^0 14'$ and $30^0 21'$ N latitude and $77^0 33.5'$ and $77^0 42.5'$ E longitudes and covers an area of 6500 ha in Saharanpur district of Uttar Pradesh. It represents a transition zone of semi-arid, sub-tropical type of climate. The mean annual soil temperature is around 26^0C with difference of winter and summer temperatures being more than 5^0C. Hence, the area qualifies for 'hyperthermic' temperature regime. The mean annual rainfall of the area is around 900 mm, more than 80 per cent of which is received during June to September. The soil moisture control section is dry for 90 cumulative days or 45 consecutive days, so the area qualifies for 'ustic' soil moisture regime. The area forms a part of the Siwalik system (lower Himalayas). The Siwalik deposits consist of alluvial detritus derived from sub-aerial wastes of the middle and upper Himalayas, swept down by rivers and streams. Information about

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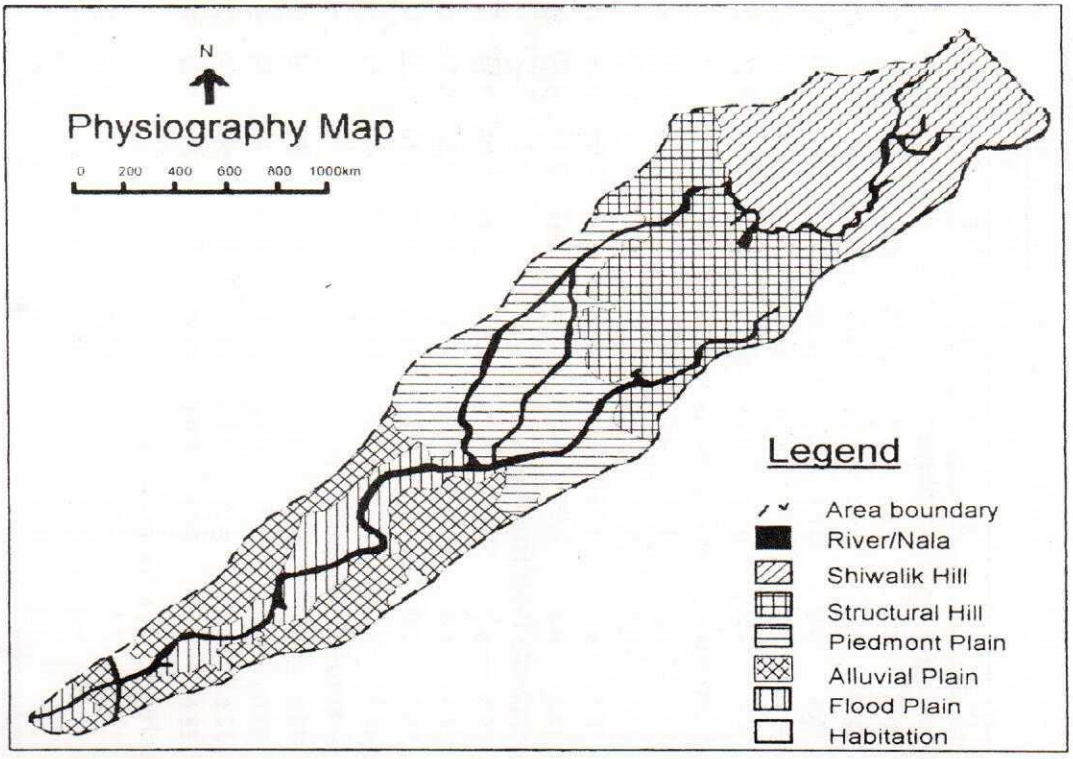

Fig. 1. Physiography map of Panja-Rao watershed of Saharanpur, Uttar Pradesh

age of these deposits is lacking. Geologists argue that these were deposited during the Pleistocene and Holocene periods (Wadia 1976). The parent material observed in the siwaliks are conglomerates whereas structural hills have ferruginous sandstone as parent material. The piedmont areas have parent material consisting of colluvium and alluvium. The alluvial and flood plains have alluvium as parent material. The natural vegetation of area comprises khair (*Acacia catechu*), ber (*Zizyphus jujuba*), amaltas (*Cassia fistula*), shisham (*Delbergia sissoo*), neem (*Azadirachta indica*) and mango (*Mangifera indica*), etc.

The IRS-ID LISS-III geo-coded False Colour Composite (FCC) of 22nd Oct. 2002 corresponding to Survey of India toposheet 53F/11 (1:50,000 scale) has been used for visual interpretation of remote sensing data. Based on interpretation of satellite image and toposheets in conjunction with ground truth, five physiographic units *viz.* Siwalik hill, structural hill, piedmont plain, alluvial plain and flood plain were delineated. The soils were studied in different physiographic units and horizon-wise soil samples were collected and analysed for particle size (Piper 1966), soil pH (1:2.5 soil water suspension) (Jackson 1958), electrical conductivity (Richards 1954), organic carbon and calcium carbonate (Piper 1966) and cation exchange capacity (Jackson 1958). The soils were classified as per Keys to Soil Taxonomy (Soil Survey Staff 1998).

Results and Discussion

Physiography

Visual interpretation of the FCC in conjunction with toposheet and geomorphological map helped in identifying five major physiographic units *viz.* Siwalik hill, structural hill, piedmont plain, alluvial plain and flood plain (Fig.1). These units were further sub-divided into sub-units based on the image characteristics. The soils in these sub-units were studied in the field through reconnaissance survey. Thirteen soil series were tentatively identified in the area. Barkala and Roshanpur-1 series occurred in the

Table 1. Morphological, physical and chemical properties of soils

Horizon	Depth (cm)	Colour	Texture	Structure	Coarse fragments (%)	Sand (%)	Silt (%)	Clay (%)	pH (1:2.5)	EC (dsm^{-1})	OC (%)	CEC [cmol p^+kg^{-1}]	Exchangeable cations [cmol p^+kg^{-1}]			
													Ca	Mg	Na	K
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Barkala series: Loamy-skeletal, mixed, hyperthermic Typic Ustorthents																
A	0-16	10YR4/2	sl	gr	10-15	61.6	30	8.4	8.3	0.02	0.76	16.24	8.98	5.04	0.20	0.16
AC2	16-38	10YR4/3	sl	f1sbk	30-35	69.6	22	8.4	8.0	0.04	0.35	14.67	7.31	4.99	0.18	0.10
AC3	38-58	10YR4/3	sl	f1sbk	40-45	65.6	24	10.4	8.0	0.04	0.32	14.36	7.32	5.00	0.18	0.11
AC4	58-78	10YR4/3	sl	f1sbk	50-55	67.6	24	8.4	7.8	0.05	0.32	15.3	8.10	5.21	0.17	0.11
AC5	78-110	10YR4/3	sl	f1sbk	65-70	67.6	24	8.4	7.8	0.04	0.14	16.55	10.30	5.27	0.16	0.10
Roshanpur1 series: Loamy-skeletal, mixed, hyperthermic Typic Haplustepts																
A	0-15	10YR3/2	sl	m2sbk	10-15	52.7	34	13.3	6.5	0.05	0.47	9.05	5.20	3.05	0.17	0.14
Bw1	15-28	10YR3/2	l	m2sbk	10-15	52.7	30	17.3	6.4	0.03	0.45	11.86	6.63	3.37	0.24	0.12
Bw2	28-70	10YR3/2	l	m2sbk	25-30	48.7	28	23.3	6.3	0.03	0.42	12.80	6.27	4.09	0.26	0.15
Bw3	70-108	10YR4/3	l	m2sbk	16-17	60.7	20	19.3	6.5	0.04	0.29	12.18	7.49	3.79	0.20	0.14
Shafipur1 series: Fine-loamy, mixed, hyperthermic Typic Haplustepts																
A	0-15	10YR4/3	sl	m2sbk	10-15	58.7	26	15.3	6.2	0.01	0.32	9.68	5.90	2.70	0.14	0.12
Bw1	15-38	10YR4/3	l	m2sbk	-	44.7	34	21.3	6.6	0.01	0.16	12.18	6.19	4.50	0.25	0.11
Bw2	38-70	10YR4/3	l	m2sbk	-	38.7	36	25.3	7.0	0.01	0.15	14.67	8.27	5.40	0.32	0.10
Bw3	70-126	10YR4/3	l	m2sbk	-	40.7	36	23.3	7.2	0.48	0.12	14.67	8.90	4.80	0.41	0.10
Shafipur2 series: Fine-loamy, mixed, hyperthermic Typic Haplustepts																
A	0-15	10YR3/3	l	f1sbk	-	45.4	34	20.6	6.2	0.02	0.76	15.30	8.00	5.59	0.25	0.19
Bw1	15-38	10YR4/4	l	m1sbk	-	53.4	28	18.6	5.8	0.01	0.22	15.92	8.04	5.97	0.38	0.12
Bw2	38-76	10YR4/4	cl	m2sbk	-	41.4	26	32.6	6.2	0.01	0.13	14.99	8.08	5.92	0.35	0.10
Bw3	76-110	10YR4/4	cl	f1sbk	-	43.4	28	28.6	6.3	0.01	0.08	15.92	8.57	6.06	0.36	0.10
Habibpur series: Fine-loamy, mixed, hyperthermic Typic Ustipsamments																
A	0-15	10YR5/3	l	f1sbk	-	49.4	22	28.6	7.1	0.03	0.45	15.30	8.42	5.48	0.33	0.07
AC1	15-40	10YR4/4	ls	sg	-	81.4	8	10.6	7.0	0.03	0.35	15.0	8.4	5.4	0.31	0.06
AC2	40-76	10YR4/4	ls	sg	-	80.3	12	8.5	6.9	0.04	0.22	14.67	8.13	5.46	0.34	0.04

contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Roshanpur2 series: Coarse-loamy, mixed, hyperthermic Typic Haplustepts																
A	0-17	10YR4/4	sl	m1sbk	-	53.4	36	10.6	5.3	0.08	0.32	13.11	8.20	3.91	0.09	0.08
Bw1	17-41	10YR4/4	l	m1sbk	-	43.2	42	14.6	5.9	0.09	0.17	14.05	8.56	4.30	0.17	0.07
Bw2	41-69	10YR4/6	l	m1sbk	-	45.4	42	12.6	6.2	0.08	0.16	12.49	8.00	3.89	0.17	0.06
2Bw3	69-89	10YR5/6	sl	m1sbk	-	57.4	30	12.6	6.2	0.07	0.12	11.55	7.69	3.31	0.14	0.07
3Bw4	89-110	10YR5/6	sl	m2sbk	-	55.4	34	10.6	6.5	0.07	0.10	11.86	7.91	3.09	0.16	0.06
Nagal series: Fine-loamy, mixed, hyperthermic Typic Haplustepts																
A	0-15	10YR4/3	sl	m1sbk	-	53.4	36	10.6	6.6	0.02	0.20	8.74	4.50	3.55	0.19	0.08
AC1	15-41	10YR3/3	sl	f1sbk	10-15	63.4	24	12.6	7.3	0.64	0.18	8.74	4.50	3.61	0.30	0.11
AC2	41-59	10YR3/3	sl	fisbk	25-30	71.4	18	10.6	7.3	0.53	0.16	8.12	4.89	2.63	0.31	0.11
AC3	59-105	10YR4/4	ls	sg	60-80	79.4	12	8.6	7.4	0.54	0.15	6.56	3.30	1.34	0.31	0.11
Roshanpur3 series: Coarse-loamy, mixed, hyperthermic Typic Haplustepts																
Ap	0-15	10YR5/2	sl	f1sbk	-	69.6	24	6.4	6.2	0.03	0.40	12.18	7.50	3.90	0.13	0.10
Bw1	15-29	10YR4/4	l	m2sbk	-	45.6	40	14.4	6.4	0.08	0.26	15.92	8.20	6.50	0.20	0.09
Bw2	29-68	10YR4/3	l	m1sbk	-	51.6	36	12.4	6.7	0.07	0.26	20.61	11.80	7.83	0.21	0.08
Bw3	68-105	10YR4/3	sl	m1sbk	-	55.6	32	12.4	7.0	0.08	0.14	16.86	10.57	5.20	0.20	0.06
Bw4	105-125	10YR4/3	sil	m1sbk	-	31.6	50	18.4	6.9	0.05	0.20	19.67	11.3	7.60	0.25	0.07
Sherpur-1 series: Coarse-loamy, mixed (calcareous), hyperthermic Fluventic Haplustepts																
Ap	0-18	10YR4/2	sl	f1sbk	-	68.7	22	9.3	8.3	0.03	0.18	9.05	5.19	2.91	0.14	0.06
Bw1	18-30	10YR5/3	sl	f1sbk	-	73.4	10	16.6	8.8	0.03	0.10	5.93	3.55	1.45	0.18	0.05
Bw2	30-45	10YR4/2	sl	m1sbk	-	79.4	6	14.6	9.0	0.03	0.06	5.62	4.44	0.45	0.19	0.04
Bw3	45-79	10YR5/3	sl	m1sbk	-	73.4	12	14.6	8.8	0.02	0.06	7.49	5.97	1.31	0.30	0.07
Bw4	79-95	10YR6/3	sl	m1sbk	10-20	81.4	4	14.6	9.1	0.03	0.03	4.68	2.36	1.32	0.20	0.04
Bw5	95-109	10YR5/3	l	m1sbk	-	37.4	48	14.6	8.5	0.04	0.15	8.74	4.73	3.07	0.50	0.12
BC	109-150	10YR4/3	sl	f1sbk	-	56.7	30	13.3	7.6	0.50	0.11	7.49	4.47	2.12	0.29	0.11
Padli-1 series: Coarse-loamy over sandy, mixed, hyperthermic Typic Haplustepts																
Ap	0-17	10YR4/3	sl	f1sbk	-	68.7	20	11.3	6.7	0.43	0.25	8.12	4.10	3.00	0.45	0.14
Bw1	17-45	10YR4/2	sl	f1sbk	-	60.7	24	15.3	6.9	0.45	0.13	11.24	6.20	4.01	0.36	0.16
Bw2	45-74	10YR4/3	sl	f1sbk	-	64.7	22	13.3	7.0	0.52	0.10	7.49	3.75	2.70	0.25	0.13
BC	74-102	10YR4/4	sl	sg	-	72.7	18	9.3	6.9	0.45	0.04	5.93	2.93	2.00	0.51	0.12
C	102-160	10YR4/4	ls	sg	-	80.7	10	9.3	6.9	0.68	0.01	6.56	4.00	1.49	0.38	0.10

contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Mirzapur series: Coarse-loamy, mixed, hyperthermic Typic Haplustepts																
Ap	0-17	10YR4/2	l	f1sbk	-	43.4	42	14.6	6.1	0.02	0.44	12.80	6.97	4.83	0.22	0.12
2Bw1	17-63	10YR4/3	l	m1sbk	-	47.4	34	18.6	6.3	0.01	0.15	11.24	6.50	3.52	0.32	0.12
3Bw2	63-83	10YR4/4	sl	m1sbk	-	57.4	26	16.6	6.3	0.57	0.13	9.68	5.48	3.12	0.32	0.14
4Bw3	83-116	10YR4/4	sl	m1sbk	-	63.4	24	12.6	6.3	0.65	0.11	9.68	5.10	3.37	0.31	0.11
5BC	116-151	10YR5/6	sl	m	-	61.4	28	10.6	6.1	0.78	0.07	9.05	4.80	2.52	0.26	0.10
Sherpur-2 series: Coarse-loamy, mixed, hyperthermic Fluventic Haplustepts																
Ap	0-15	10YR4/3	l	f1sbk	-	50.7	38	11.3	7.1	0.91	0.44	14.05	8.34	4.66	0.17	0.23
2Bw1	15-47	10YR4/3	sl	f1sbk	-	60.7	28	11.3	7.5	0.02	0.15	9.68	5.05	3.63	0.24	0.11
3Bw2	47-88	10YR5/3	sl	m1sbk	-	66.7	26	7.3	7.6	0.01	0.07	10.62	6.42	3.38	0.25	0.08
4Bw3	88-107	2.5Y5/4	sl	m1sbk	-	69.4	14	16.6	8.5	0.01	0.03	8.47	5.10	2.78	0.27	0.08
5Bw4	107-136	2.5Y4/4	l	f1sbk	-	39.4	34	16.6	8.5	0.43	0.03	11.24	7.70	2.60	0.44	0.13
6Bw5	136-152	2.5Y4/4	sicl	f1sbk	-	14.7	58	27.3	8.3	0.35	0.22	12.11	7.10	3.20	0.57	0.16
Padli-2 series: Coarse-loamy, mixed, hyperthermic Typic Ustifluvents																
Ap	0-15	10YR4/3	sl	f1sbk	-	73.4	12	14.6	7.7	0.02	0.16	5.93	3.29	1.48	0.26	0.08
2AC1	15-42	10YR5/4	ls	m	-	53.4	8	8.6	8.4	0.04	0.16	5.62	3.10	1.99	0.12	0.07
3AC2	42-58	10YR4/4	sl	f1sbk	-	58.7	32	9.3	7.8	0.01	0.15	9.37	5.61	2.89	0.13	0.12
4AC3	58-89	10YR5/4	sl	m	-	81.4	8	10.6	8.9	0.05	0.07	4.37	2.43	1.39	0.31	0.03
C1	89-117	10YR5/4	s	m	25-30	90.7	4	5.3	9.0	0.03	0.03	5.00	3.00	1.25	0.13	0.04
C2	117-150	10YR4/3	sicl	m	40-50	16.7	52	31.3	7.8	0.02	0.03	20.29	11.00	7.71	0.14	0.13

Siwalik Hill; Shafipur-1, Shafipur-2 and Habibpur series in the structural hill; Roshanpur-2, Nagal, Roshanpur-3 and Sherpur-1 in the piedmont plain; Padli1, Mirzapur and Sherpur-2 in the alluvial plain and Padli-2 in the flood plain. Similar soil-physiographic relationship have been reported for siwalik piedmont of semi-arid tract of Punjab (Sawhney *et al.* 2005).

Morphological properties

The soils of the Siwalik hill were very deep (> 100 cm) (Table 1). Soils in the structural hills are very deep (Shafipur1 series), however, the degraded structural hills have deep to moderately deep soils (Shafipur-2 and Habibpur series). The soils in the piedmont, alluvial and flood plain were found to be very deep and are developed on relatively stable landforms. All the soils have their colour in 10YR hue except Bw horizon of in Sherpur-2 series (2.5 Y) The structural changes in B horizon are prominent in all soils except Barkala, Hibibpur, Nagal and Padli-2 series.

Physical characteristics

The particle-size data (Table 1) indicated that the sand, silt and clay content in soils varied from 14.7 to 90.7, 4.0 to 58.0 and 5.3 to 32.6 per cent, respectively. In general, sub-surface horizons had higher clay content as compared to surface layer. In the flood plain areas, the texture is sandy loam with high sand content (78.0%). Correlation studies indicated that the silt content was significantly and positively correlated (at 1% level) with CEC (r =0.58), exch. Ca (r=0.59), exch. Mg (r=0.54) and exch. K (r=0.43). Similarly, the clay content of the soil was significantly and positively correlated (at 1% level) with CEC (r= 0.36), exch. Ca (r =0.32), exch. Mg (r =0.37), exch. Na (r=0.34) and exch. K (r=0.25).

Chemical properties

The electrical conductivity of soils varies from 0.01 to 0.91 dS m^{-1} (Table 1). In the Sherpur-2 series the high value of electrical conductivity (0.91 dS m^{-1}) is due to use of ground water for irrigation. It was observed that the electrical conductivity values were negatively correlated with exch. Ca (r = -0.26) and exch. Mg (r = -0.25) (at 5% level) but significantly and positively correlated with exch. Na (r = 0.38) and exch. K (r = 0.41) (at 1% level). The pH of soils varied from 5.3 to 9.1. Among the series, Sherpur-1 showed higher pH due to presence of $CaCO_3$ up to fifth layer. The CEC varied from 5.9-20.3 cmol(p^+)kg^{-1}. Low values of CEC may be ascribed to the pre-dominance of low CEC minerals especially illite in these soils (Karan-Singh 1987). Correlation studies showed that CEC was significantly and positively correlated with exch. Ca (r = 0.96), exch. Mg (r = 0.96) and available N (r = 0.47) at 1% level. The per cent organic carbon content in surface and sub-surface soils varied from 0.16 to 0.76 and 0.01 to 0.45, respectively. The carbon content was relatively higher in hill soil than that of piedmont and alluvial one. This may be attributed to the luxuriant vegetation and relatively low temperature conditions favouring slow rate of decomposition. Similar findings have also been reported by Minhas (1986) for forest soils of Himachal Pradesh. Correlation studies showed that the per cent organic carbon content was significantly and positively correlated with CEC (r = 0.39), exch. Mg (r = 0.38), exch. K (r = 0.42), available N (r = 0.80), available P (r = 0.35), available Zn (r = 0.64), available Fe (r = 0.48), available Cu (r = 0.46) and available Mn (r = 0.41) at 1% level.

Classification of the soils

Soils of Siwalik Hill

These soils have been demarked as 'a1' mapping unit (Fig. 2) and have association of Barkala and Roshanpur-1 soil series. The soils of Barkala series comprise excessively drained, very deep, coarse loamy soils of dark grayish brown to brown colour and have no diagnostic horizons. Thus, the soils belong to Entisol order and classified as loamy- skeletal, mixed, hyperthermic family of Typic Ustorthents. The soils of Rosanpur-1 series are very deep, excessively drained, have very dark grayish brown colour with medium sub-angular blocky structure and cambic sub-surface horizon. Thus, the soils belong to Inceptisol order and

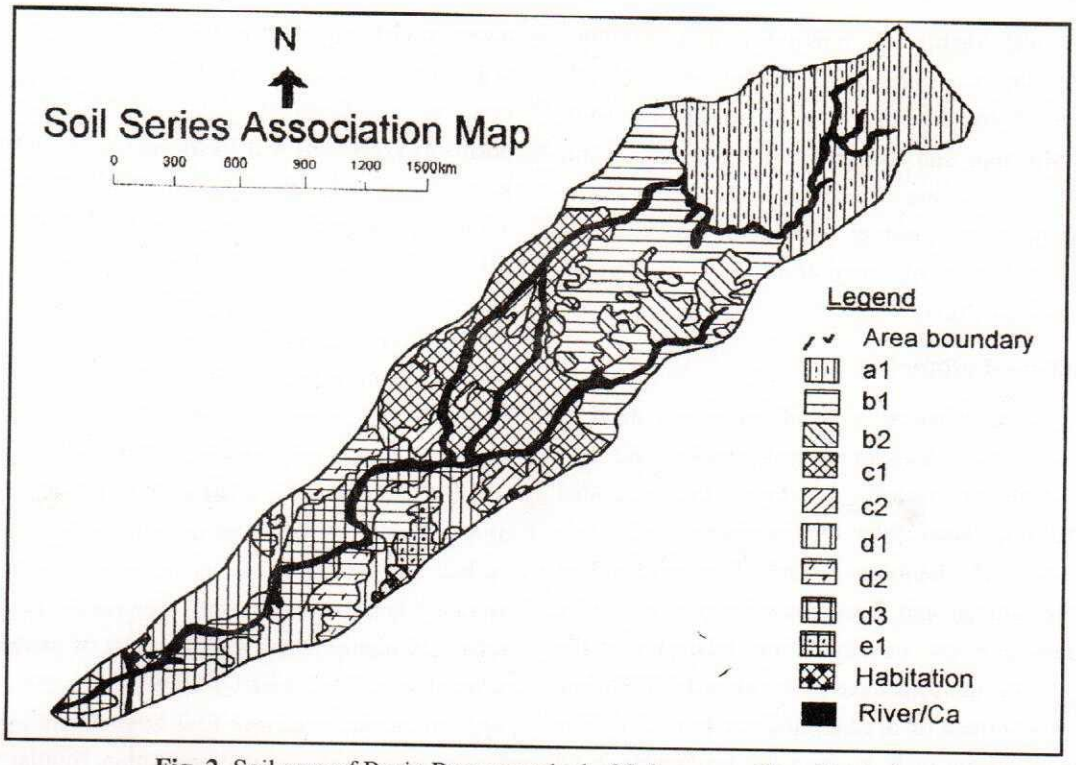

Fig. 2. Soil map of Panja-Rao watershed of Saharanpur, Uttar Pradesh

classified as loamy-skeletal, mixed, hyperthermic family of Typic Haplustepts.

Soils of Structural Hill

The soil in the structural hills has been demarked as 'b' mapping unit which is further sub-divided as b1 and b2 mapping units (Fig. 2). The b1 unit represents normal areas and has association of Shafipur-1 and Shafipur-2 series and the b2 unit represents areas having some degradation and is association of Shafipur-2 and Habibpur series. The soils of Shafipur-1 series are very deep, well drained, have brown to dark brown colour with medium sub-angular blocky structure and structural B horizon. Thus, the soils belong to Inceptisol order and have been classified as fine-loamy, mixed, hyperthermic family of Typic Haplustepts. The soils of Shafipur-2 series are deep, well drained, have dark brown in the surface to dark yellowish brown colour in the sub-surface horizon with weak to medium sub-angular blocky structure. Thus, the soils belong to Inceptisol order and have been classified as fine-loamy, mixed, hyperthermic family of Typic Haplustepts. The soils of Habibpur series are moderately deep, well drained, have brown in the surface to dark yellowish brown colour in sub-surface horizon with weak sub-angular blocky structure. The soils have A horizon up to hard unconsolidated rock and thus belong to Entisol order and has classified as fine-loamy, mixed, hyperthermic family of Typic Ustipsamments.

Soils of Piedmont Plain

The soils in the piedmont plain have been demarked as 'c' mapping unit and further sub-divided into c1 and c2 mapping units (Fig. 2). The c1 mapping unit consists of open scrub areas and c2 unit represents where agriculture is practiced. The c1 mapping unit has association of two series, namely Roshanpur-2 and Nagal. The soils of Roshanpur-2 series are very deep, excessively drained, have dark yellowish brown colour in the surface to yellowish brown colour in the sub-surface horizon with weak, sub-angular blocky structure in the B horizon. Thus the soils belong to Inceptisol order and have been classified as coarse-loamy mixed hyperthermic family of Typic Haplustepts. Soils of Nagal series are very deep, well

drained, have brown to dark brown colour in the surface and dark brown to dark yellowish brown colour in the sub-surface horizons. Coarse fragments (10 to 15%) are observed in the AC2 horizon and increased up to 60% in the C horizon. The texture is sandy loam up to depth of 60 cm and then loamy sand to a depth of 104 cm. There is no development of soil structure and hence the soils belong to Entisol order and have been classified as loamy-skeletal, mixed, hyperthermic family of Typic Ustorthents.

Soils of Alluvial Plains

The soils in the alluvial plain has been demarcated as 'd' mapping unit (Fig.2) and further sub-divided into d_1, d_2 and d_3 mapping unit. The d_1 mapping unit represents rainfed agricultural lands of alluvial plain, d_2 mapping unit as irrigated agricultural lands and d_3 as orchards and other plantation crops. The d_1 mapping unit is represented by Padli-1 series. The soils in this series are very deep, well drained, have brown colour on the surface and dark grayish brown to dark yellowish brown colour in the sub-surface horizon. The texture of the soils are uniformly sandy loam from surface to sub-surface, and has very weak development of structure in the sub-surface horizons. The soils are non-calcareous and has been classified as coarse-loamy over sandy, mixed, hyperthermic family of Typic Ustorthents. The soils of Mirzapur series are represented by d_2 mapping unit. Irrigated agriculture is practiced in this soil. The soils are very deep, well drained, have dark grayish brown colour on the surface to dark yellowish brown in the B horizon and yellowish brown colour in the BC horizon. The soils have medium, sub-angular blocky structure in the sub-surface horizons. The soils are non-calcareous and there is an improvement of soil structure down the profile which qualifies for structural B horizon and hence soils belong to Inceptisol order and has been classified as coarse-loamy, mixed, hyperthermic family of Typic Haplustepts. The soils in d_3 unit occur in orchards and plantation areas. Sherpur-2 is the representative series of this unit. Sherpur-2 soils are very deep, well drained and have dark brown colour on the surface. The sub-surface colour ranges from brown to dark brown to olive brown. The soil structure has improved down the profile giving rise to structural B horizon. The organic carbon distribution is irregular which indicate the fluventic characteristic of soils. Soils belong to Inceptisol order and are classified as coarse-loamy, mixed, hyperthermic family of Fluventic Haplustepts.

Soils of flood plain

The flood plains have been demarcated as 'c' unit and further sub-divided in to c1 and c2 mapping units (Fig.2). The area has lighter tone on the satellite imagery due to presence of coarse and light textured material. This area covers both sides of Panja Rao river. The soils are very deep, well drained and have brown to dark brown colour on the surface and yellowish brown to dark brown colour in the subsurface horizons. The texture of the soils is sandy loam on the surface. The structure is very weak which is either single grain and massive with depth. The distribution of organic carbon content also shows no regular pattern. The irregular distribution pattern reveals that the soils are fluventic in nature. The soils have been classified as coarse-loamy, mixed, hyperthermic family of Typic Ustifluvents.

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